Rosenbluth Separation of electropion production cross-section from Hydrogen and Carbon

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On the behalf of Jefferson Laboratory E01-107 collaboration

- Introduction
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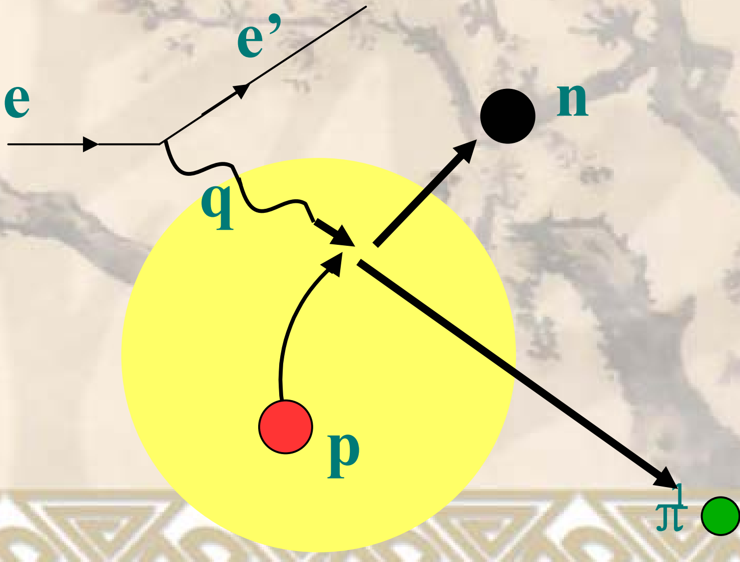
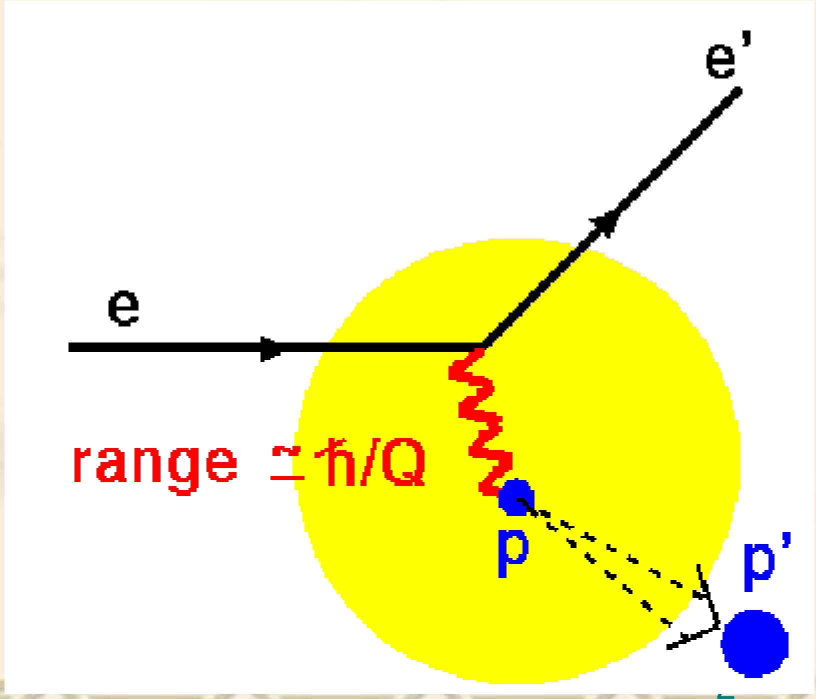


Motivation of E01-107

- Search for Color-Transparency
- **Colour Transparency is a phenomenon predicted by QCD in which hadrons produced at large momentum transfer can pass through nuclear matter with little or no interaction**

- $\bar{q}q$ or qqq that have small transverse size are preferentially selected at large Q^2 **(Quantum mechanics)**
- The hadron can propagate out of the nucleus before returning to its equilibrium size **(Relativity)**
- Reduced interaction, $\sigma_{PLC} \propto (r_{PLC})^2$



Motivation of Rosenbluth Separation

- Measuring Nuclear Transparency
  - Nuclear Transparency is defined by :

$$R_T = \frac{Y_{data}^{nucleus} / \boxed{Y_{SIMC}^{nucleus}}}{Y_{data}^{hydrogen} / Y_{SIMC}^{hydrogen}}$$

    - Expected Yield can be calculated used realistic nucleon momentum distributions **under quasi-free assumption**.
  - Quasi-free assumption can be verified by carrying out Rosenbluth separation.

$$\frac{\sigma_L^{hydrogen}}{\sigma_T^{hydrogen}} \sim \frac{\sigma_L^{nucleus}}{\sigma_T^{nucleus}}$$

Kinematics

- Electro pion five-fold DXs can be written as:

$$\frac{d^5\sigma}{d\Omega_e dE_e d\Omega_\pi} = \Gamma \frac{d^2\sigma}{d\Omega_\pi}$$

Γ : virtual photon flux.

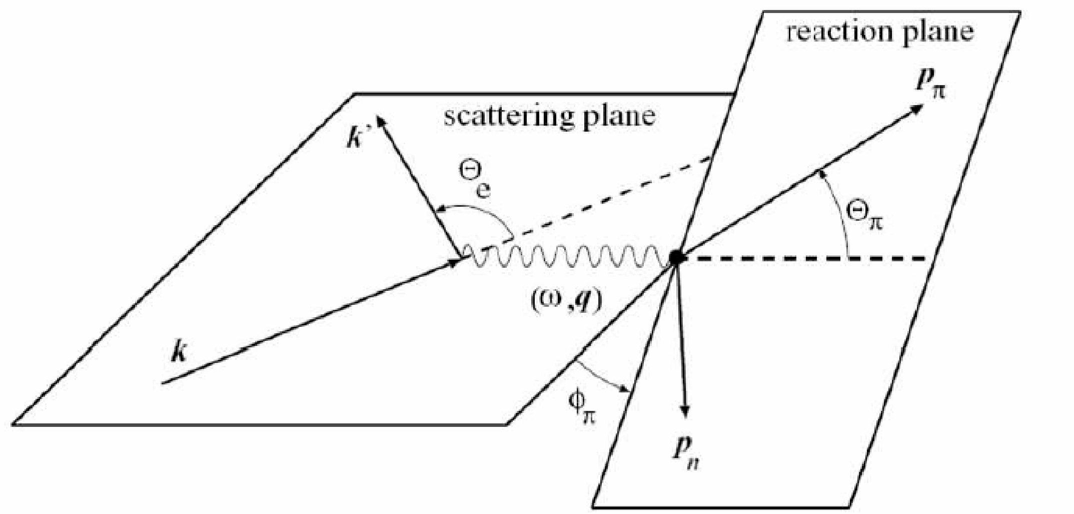


FIGURE 1. The $(e, e'\pi)$ reaction in lab frame.

- Photo pion DXs can be decomposed by virtual photon polarization:

In parallel kinematics ($\theta_\pi = 0$)

$$\frac{d^2\sigma}{d\Omega_\pi} = \epsilon\frac{d^2\sigma_L}{d\Omega_\pi} + \frac{d^2\sigma_T}{d\Omega_\pi} + \cancel{\sqrt{2\epsilon(\epsilon+1)}\frac{d^2\sigma_{LT}}{d\Omega_\pi}\cos(\phi_\pi)} + \cancel{\epsilon\frac{d^2\sigma_{TT}}{d\Omega_\pi}\cos(2\phi_\pi)}$$

ε : virtual photon polarization

Rosenbluth Separation

- By performing experiment at two values of virtual photon polarization, we can extract longitudinal and transverse electro-pion production DXs:

$$< \frac{d^2\sigma_L}{d\Omega_\pi} >= \frac{< \frac{d^2\sigma_1}{d\Omega_\pi} > - < \frac{d^2\sigma_2}{d\Omega_\pi} >}{< \epsilon_1 > - < \epsilon_2 >}$$

$$< \frac{d^2\sigma_T}{d\Omega_\pi} >= \frac{< \frac{d^2\sigma_1}{d\Omega_\pi} > \cdot < \epsilon_2 > - < \frac{d^2\sigma_2}{d\Omega_\pi} > \cdot < \epsilon_1 >}{< \epsilon_1 > - < \epsilon_2 >}$$

Overview of E01-107

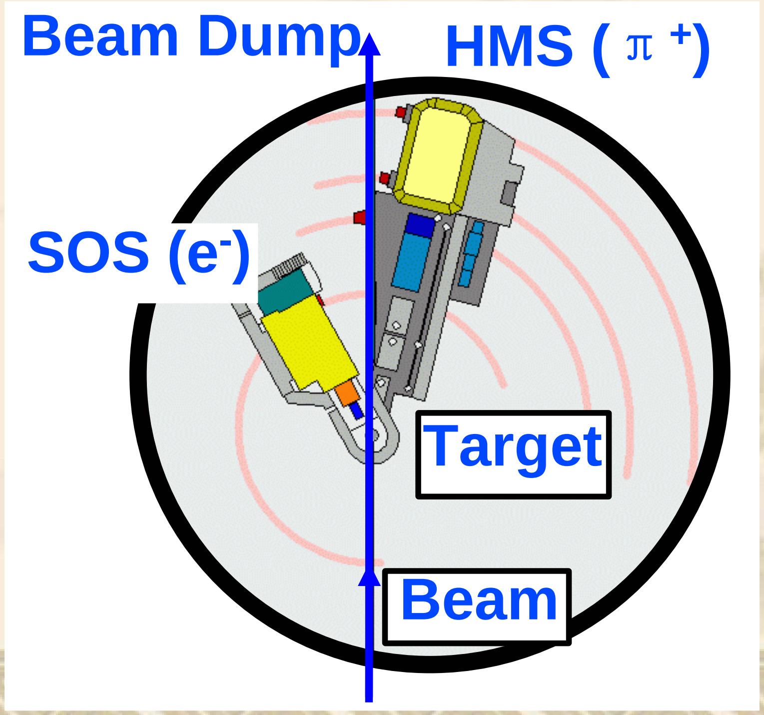
- Spokespersons: *D. Dutta*, *R. Ent* and *K. Garrow*
- Experiment ran at Jefferson Lab in Hall C in 2004
- Standard Hall C equipment was used

$(e,e'\ \pi^+)$

Electron beam energy
(4.0 to 5.8 GeV)

Electron in the SOS
(0.73 to 1.73 GeV/c)

Pion in the HMS
(2.1 to 4.4 GeV/c)



Kinematics

LH_2, LD_2, ^{12}C, ^{63}Cu and ^{197}Au targets at each kinematic setting

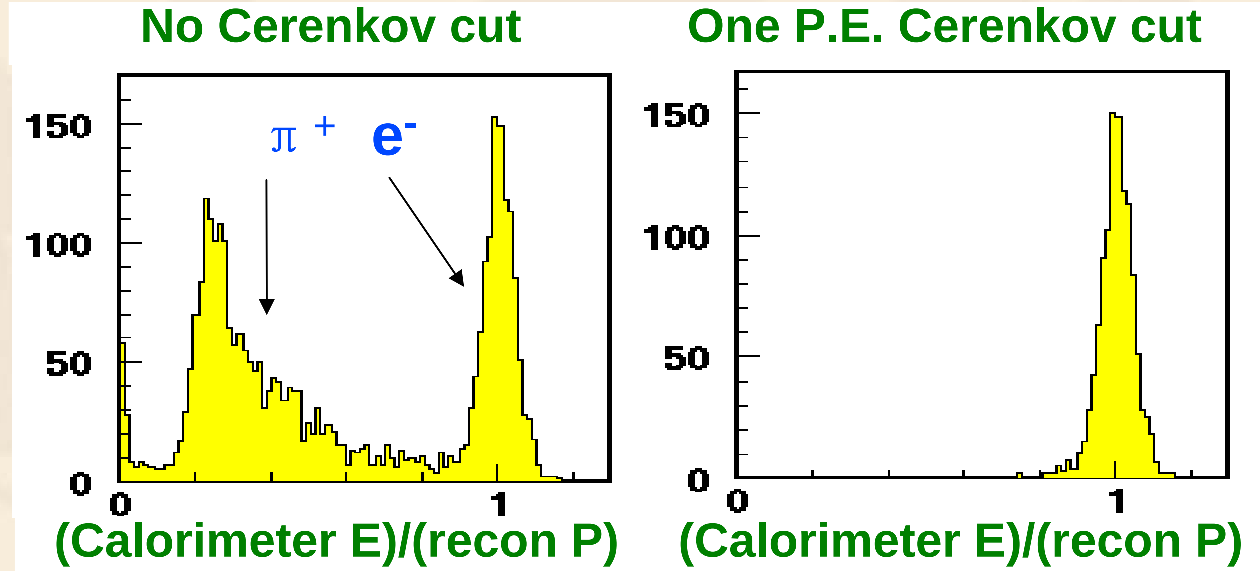
	Q^2 (GeV^2)	W (GeV)	-t (GeV^2)	E_{beam} (GeV)	θ_{hms} (deg)	P_{hms} (GeV/c)	θ_{sos} (deg)	P_{sos} (GeV/c)		x_{BJ}
	1.1	2.3	0.05	4.0	10.6	2.8	27.8	-1.2	0.50	0.21
	2.15	2.2	0.16	5.0	13.4	3.2	28.9	-1.7	0.56	0.35
	3.0	2.1	0.29	5.0	12.7	3.4	37.8	-1.4	0.45	0.44
	4.0	2.2	0.40	5.8	11.5	4.1	40.4	-1.5	0.39	0.50
	4.8	2.2	0.52	5.8	10.6	4.4	52.7	-1.1	0.26	0.54
L-T separation	2.15	2.2	0.16	4.0	10.6	3.2	50.8	-0.7	0.27	0.35
L-T separation	4.0	2.1	0.44	5.0	10.6	3.9	55.9	-0.9	0.25	0.52
W vs k_π test point	2.15	1.7	0.37	4.0	20.0	2.1	32.3	-1.7	0.63	0.50

(k_π = momentum of the virtual pion)

Particle Identification (PID)

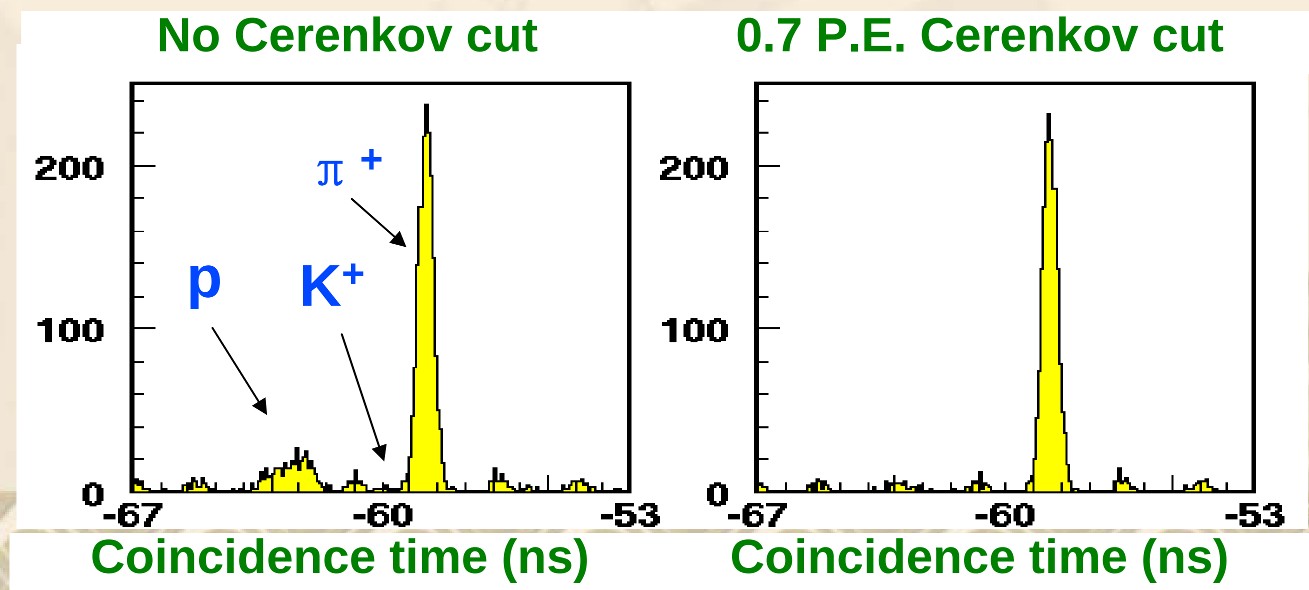
Electron arm (SOS) at 1.4 GeV

Cerenkov effic = 99.4%

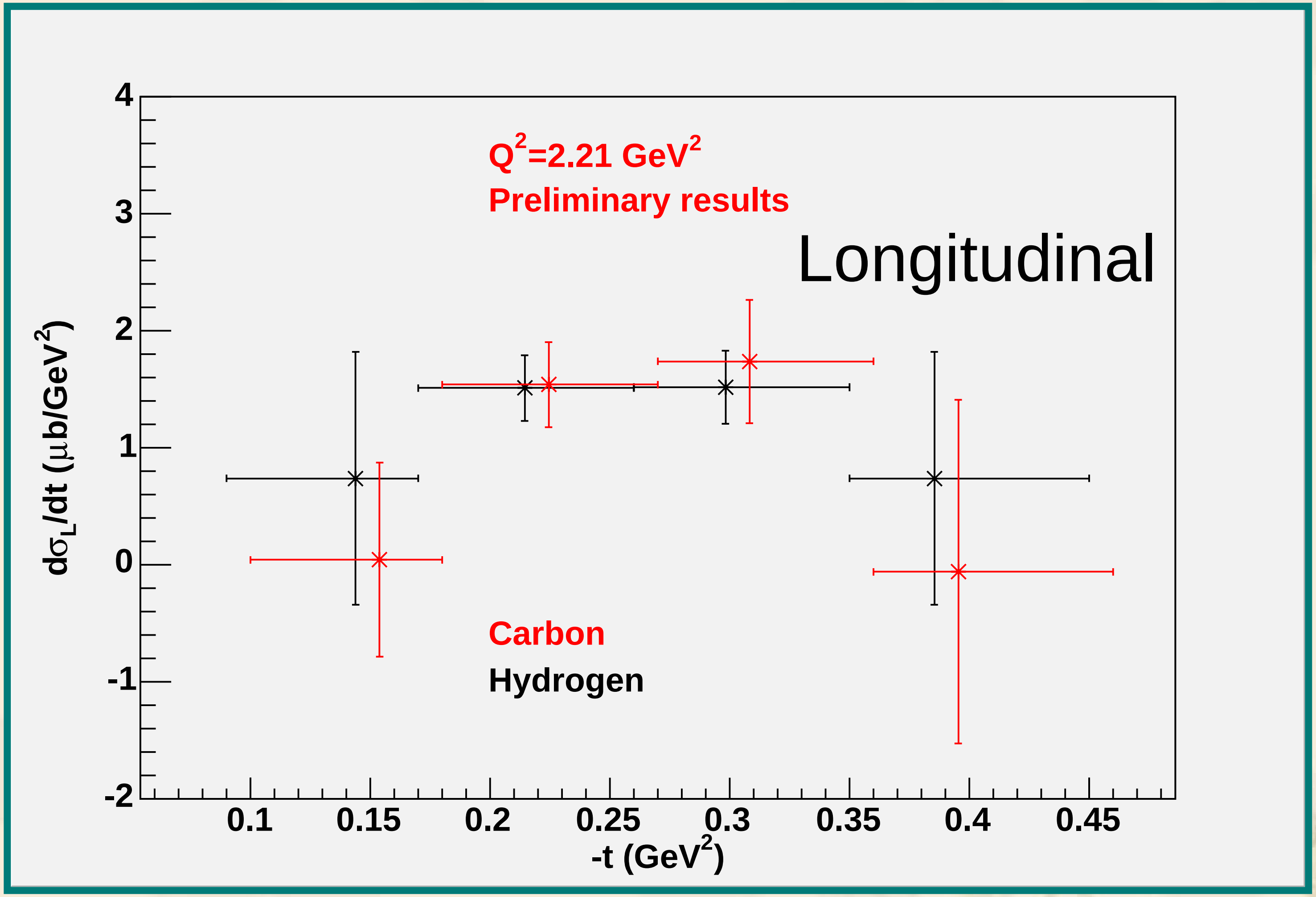


Pion arm (HMS) at 3.2 GeV

Cerenkov effic = 98.5%



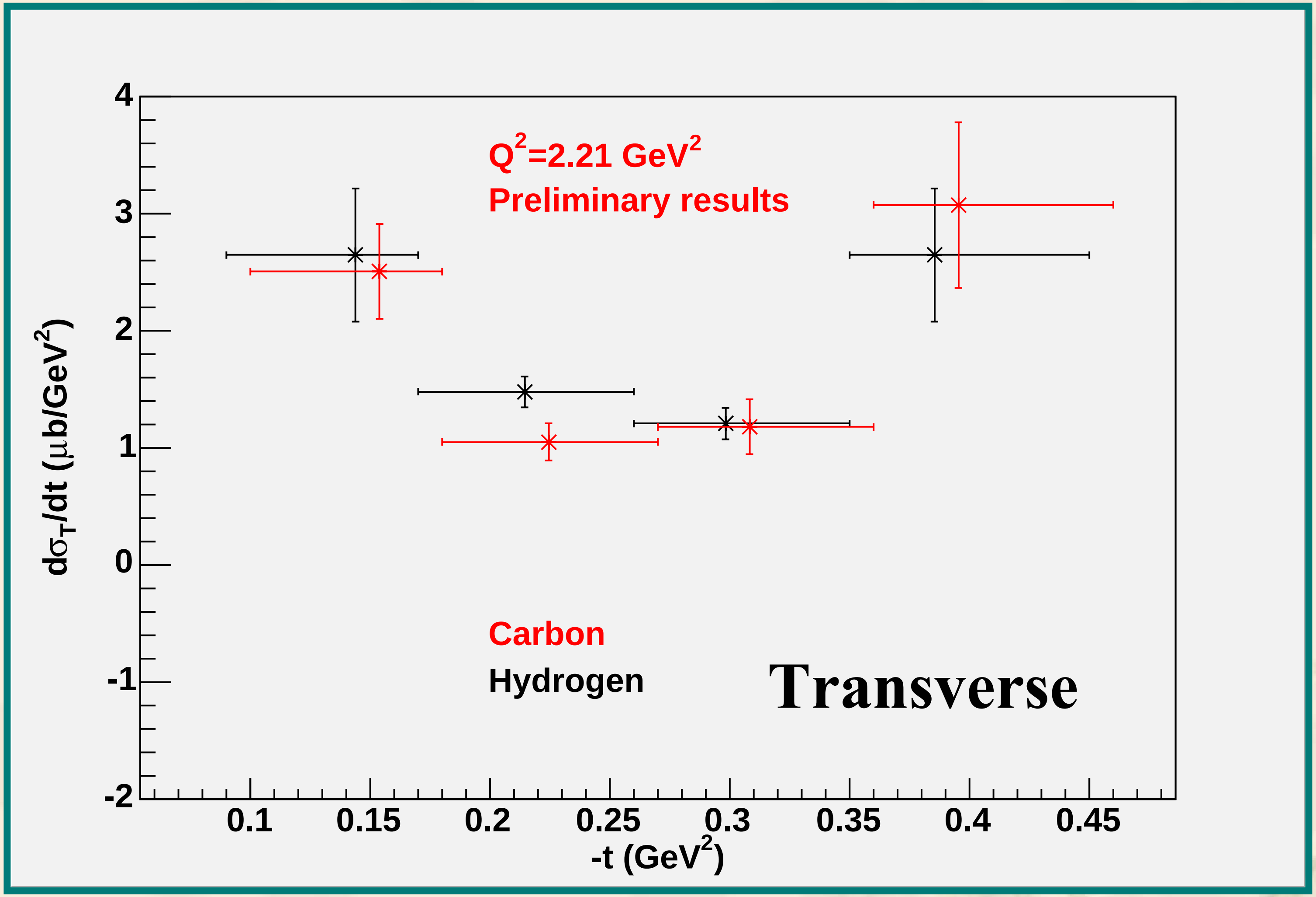
Preliminary results at Q^2 =2.15 GeV^2



statistical uncertainties only

Carbon points have be shifted by 0.01 for clarity

Preliminary results at $Q^2 = 2.15$ GeV^2



statistical uncertainties only

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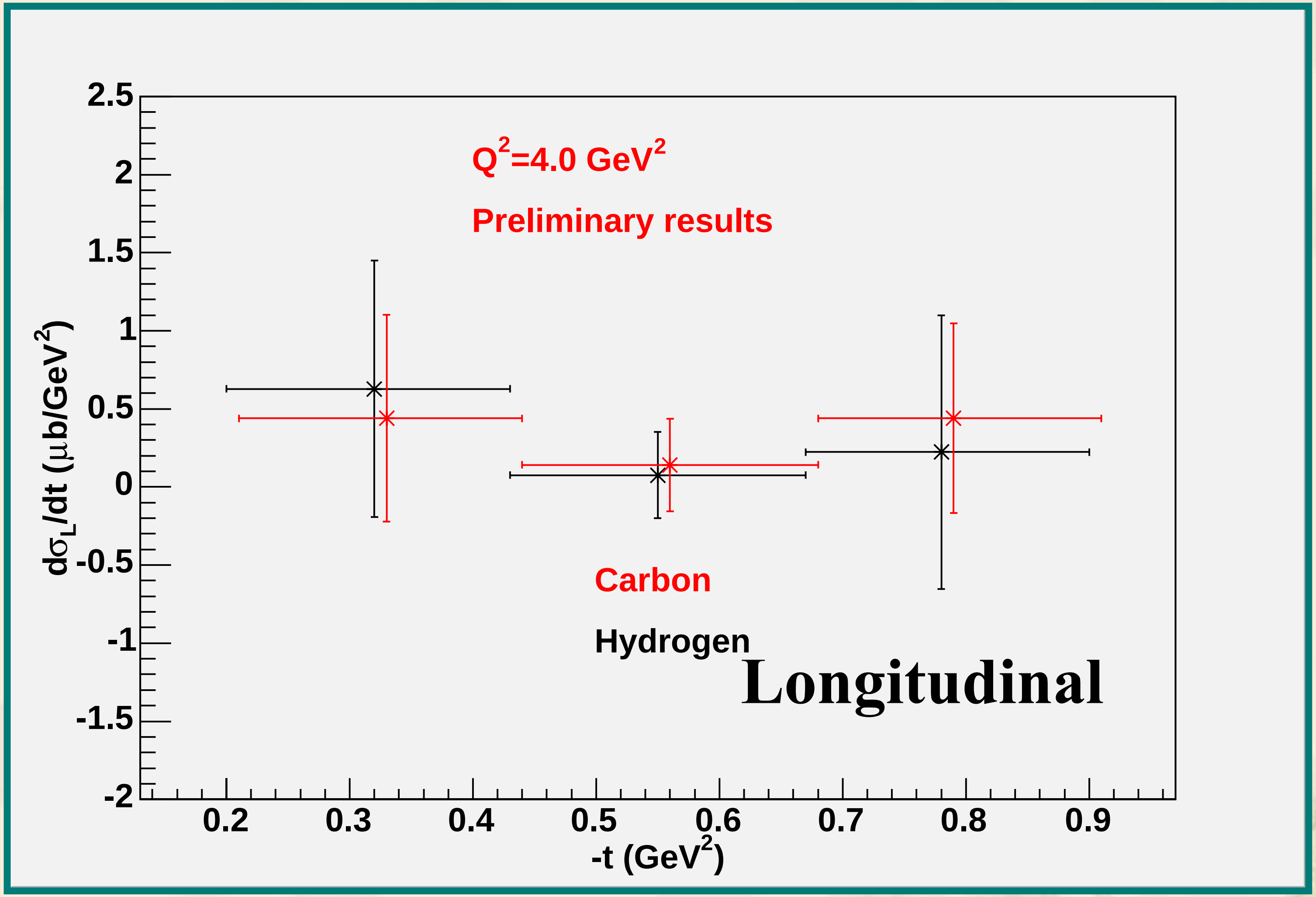
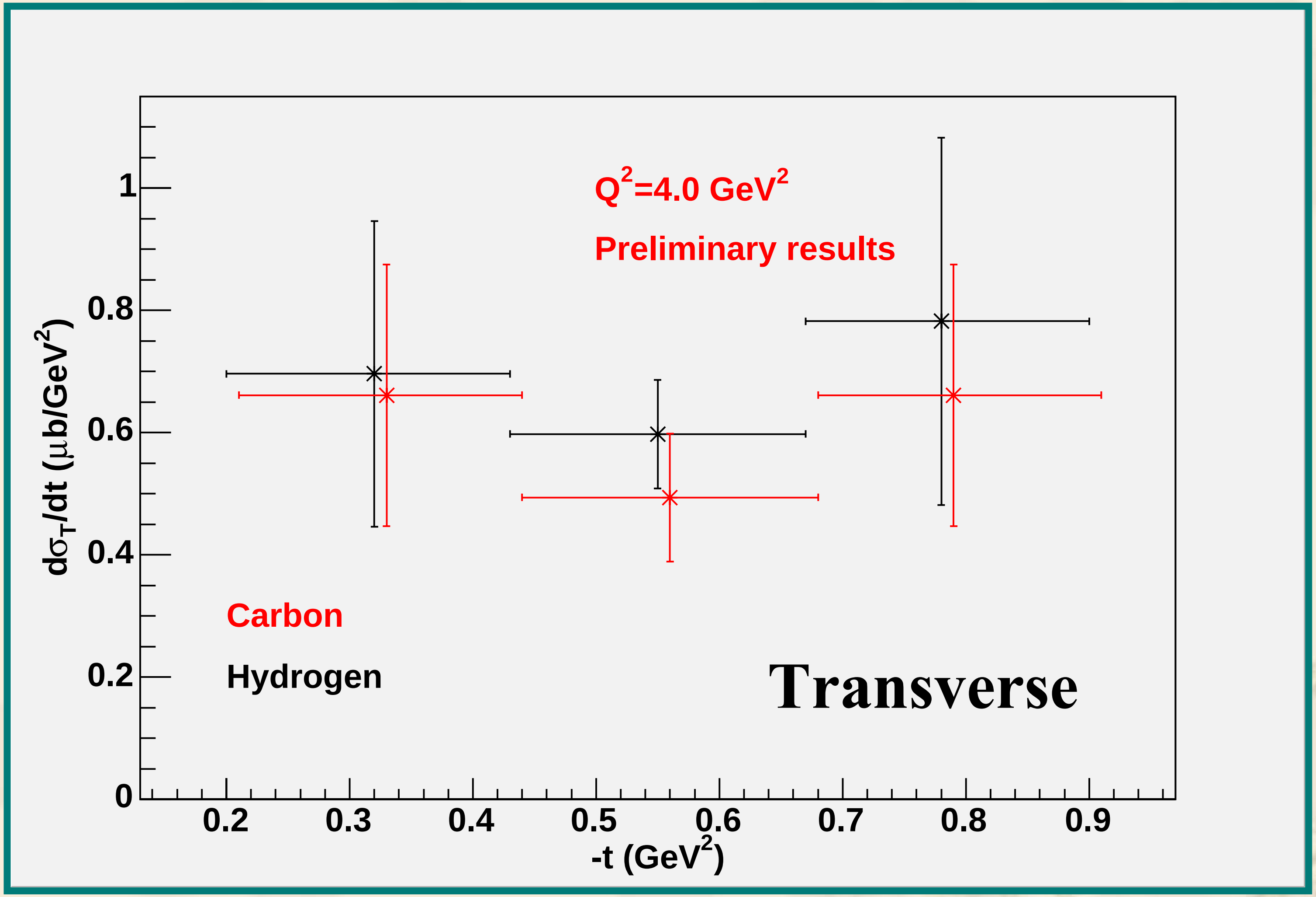
Preliminary results at Q^2 =4.0 GeV^2



statistical uncertainties only

Carbon points have be shifted by 0.01 for clarity

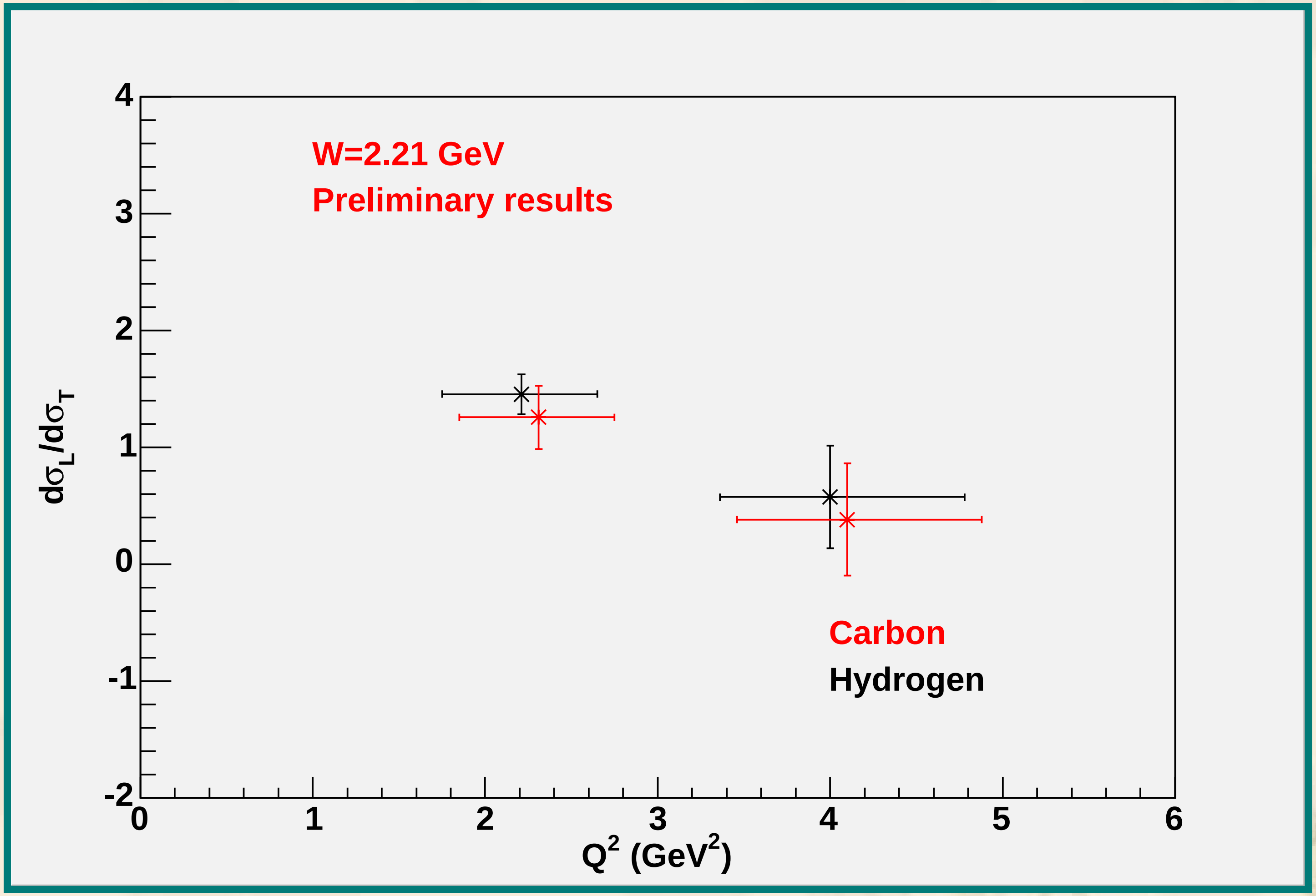
Preliminary results at Q^2 =4.0 GeV^2



statistical uncertainties only

Carbon points have be shifted by 0.01 for clarity

Preliminary results on ratio



statistical uncertainties only

Carbon points have be shifted by 0.1 for clarity

Summary

- **E01-107 will provide the FIRST nuclear transparency data from (e,e π^+) reactions.**
- **Rosenbluth separation has been carried out for the first time with (e,e' π^+) on Carbon at Q^2 = 2.15 and 4.0 GeV^2 and Hydrogen at Q^2 = 4.0 GeV^2.**
- **Preliminary results are in good agreement with quasi-free assumptions for Q^2 = 2.15 and 4.0 GeV^2.**
- **Rosenbluth separation for Copper and Gold targets will be carried out in the near future.**

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Systematic uncertainty estimation

- SOS Cerenkov Efficiency 0.5 (pt to pt)
- HMS Cerenkov Efficiency 1.0 (pt to pt)
- Charge 1.0 (Normalization)
- Target thickness 1.0 (Normalization)
- HMS and SOS trigger efficiency 2.0 (Pt to Pt)
- Computer dead time 0.1
- Coincidence blocking 0.1
- Tracking efficiency 0.5
- Pion absorption 3.0 (normalization)
- Pion absorption (between target) 1.0
- Kinematics Ebeam 0.5
- Kinematics sstheta 0.5

Hydrogen DXs: 7.99 %

- Kinematics spcentral 0.5
- Kinematics hstheta 0.3
- Kinematics hpcentral 0.3
- Pion decay 2.0 (Pt to Pt)
- Collimator punch-through 3.0 (Pt to Pt)
- Radiative correction 2.5 (Pt to Pt)
- Acceptance 5.0 (Pt to Pt)
- Dummy subtraction 0.2 (Pt to Pt)
- HMS electronic dead time 0.4
- SOS electronic dead time 0.3
- Target boiling 1.0 (Normalization)
- Carbon spectral function 1.0 (Normalization)
- Model dependence 10.0

Carbon DXs: 12.84 %

The estimated systematic uncertainties at this stage are 7% pt-pt, 3.6% normalization and 10% model dependent. We expect to improve several of these uncertainties.